1. INTRODUCTION AND OBJECTIVES

This report identifies, develops, and evaluates remedial technologies and alternatives that will eliminate or reduce to acceptable levels risks to human health or the environment posed by releases or potential releases of contaminants in Quadrant I at the Portsmouth Gaseous Diffusion Plant (PORTS), which is owned by the U.S. Department of Energy (DOE). PORTS is approximately 80 miles south of Columbus, 20 miles north of Portsmouth, and 1 mile east of U.S. Route 23, near Piketon in south-central Ohio (Figure 1.1). The industrialized portion of PORTS is approximately 1,000 acres of a 3,714-acre DOE reservation. PORTS was constructed between 1952 and 1956 and has operated since January 1955 enriching uranium for electrical power generation. Until 1991, PORTS also provided highly enriched uranium to the U.S. Navy.

On October 24, 1992, the Energy Policy Act (Public Law 102-486) amended the Atomic Energy Act of 1954 and established the United States Enrichment Corporation (USEC). USEC assumed responsibility for uranium enrichment operations at PORTS on July 1, 1993. In response, Martin Marietta Energy Systems, Inc. (Energy Systems), reorganized and created Martin Marietta Utility Services, Inc., to manage enrichment operations for the USEC. In 1995, by way of a corporate merger, Martin Marietta Energy Systems became Lockheed Martin Energy Systems (Energy Systems) and Martin Marietta Utility Services, Inc., became Lockheed Martin Utility Services. DOE remains the owner of the site and operates all facilities not leased to USEC. DOE is responsible for all response and corrective actions with respect to contamination or releases arising from past operations. Energy Systems managed environmental restoration and waste management activities at PORTS until April 1, 1998, when Bechtel Jacobs Company LLC became the management and integration contractor for DOE.

1.1 REGULATORY AUTHORITY AND STATEMENT OF PURPOSE

In 1984, DOE relinquished oversight of non-nuclear program elements to the state and federal regulators. As a result, numerous compliance inspections have been made by the Ohio Environmental Protection Agency (Ohio EPA) and the U.S. Environmental Protection Agency (U.S. EPA). To meet Resource Conservation and Recovery Act of 1976 (RCRA) operating requirements, DOE submitted a notification of hazardous waste activity at the facility as outlined in Section 3010(a) of RCRA and Title 42 *United States Code* (USC) Section 6930(a) on August 18, 1980. On July 12, 1984, DOE filed a RCRA Part A Permit application, as required by Section 3005(a) of RCRA and 42 USC Section 6925(a), to store
Figure 1.1 Site Location Map, PORTS

hazardous waste at PORTS (the most recent Part A Permit application revision was submitted December 12, 1996). DOE submitted the required RCRA Part B Permit application to the Ohio EPA on July 26, 1993. The Ohio EPA subsequently transmitted the application to the Ohio Hazardous Waste Facility Board. On July 21, 1995, the Board approved the permit. The RCRA Part B permit was issued to DOE on August 21, 1995. Numerous permit-change requests have been submitted to the Ohio EPA from DOE since the permit was issued.

The environmental restoration program at PORTS is the subject of two enforcement actions. The State of Ohio issued a Consent Decree August 31, 1989, requiring a Cleanup Alternatives Study (CAS). An Administrative Order by Consent (AOC) between the U.S. EPA and DOE under the authority of Section 3008(h) of RCRA and Sections 104 and 106(a) of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 was issued effective September 27, 1989, and amended May 11, 1994 and on August 11, 1997. The U.S. EPA AOC includes requirements for a Corrective Measures Study (CMS) for solid waste management units (SWMUs) that parallel requirements of the state of Ohio Consent Decree. Tasks in the AOC are patterned after the proposed RCRA corrective action process to be promulgated in Title 40 *Code of Federal Regulations* (CFR) Part 264 Subpart S. The AOC also requires that CERCLA requirements be integrated into the corrective action process as applicable or relevant and appropriate requirements (ARARs) or regulatory drivers to address releases of hazardous substances that are not hazardous waste. The intent of implementing CERCLA guidance at PORTS is to supplement policies and decisions not specifically included under RCRA.

The Ohio Consent Decree and the AOC specify that the investigation, study, and implementation of corrective actions should proceed in a phased approach that divides the facility into quadrants (Figure 1.2). These quadrants generally conform to the groundwater flow patterns and locations of existing facilities, as defined in the *Groundwater Quality Assessment for Four RCRA Sites* (Energy Systems 1989). The Ohio EPA and the U.S. EPA have agreed to a combined document for each quadrant to fulfill requirements of the remedial alternatives study—a CAS/CMS report. To expedite decisions that affect the schedule or content of environmental restoration documents, the Quadrant I CAS/CMS effort included the formation of a PORTS Decision Team consisting of the Ohio EPA, the U.S. EPA, and DOE representatives. The Decision Team met periodically to discuss and resolve issues necessary for continued progress in environmental investigation and remediation efforts.

Figure 1.2 Quadrant Map, PORTS

At PORTS, hazardous wastes, hazardous constituents, hazardous substances, industrial wastes, and radionuclides are collectively referred to as "contaminants." The study documented in this report identified, developed, and evaluated remedial technologies and alternatives that will eliminate or reduce risks to human health or the environment posed by releases of contaminants in Quadrant I at PORTS.

The *Quadrant I CAS/CMS Work Plan* (DOE 1993) for this study describes the methodology used in selecting and evaluating technologies and alternatives. This CAS/CMS also summarizes results of the PORTS Decision Team deliberations applicable to Quadrant I.

This CAS/CMS generally follows the approach envisioned for a RCRA site; however, CERCLA terminology and processes are incorporated for situations or contaminants not included under RCRA. This CAS/CMS relies on data contained in the following documents:

- *Quadrant I RCRA Facility Investigation Final Report* (DOE 1996a),
- *Baseline Ecological Risk Assessment* (DOE 1996b),
- *Background Sampling Investigation of Soil and Groundwater Final Report* (DOE 1996c),
- *Quadrant I Description of Current Conditions for the Portsmouth Gaseous Diffusion Plant* (Geraghty & Miller, Inc. 1992a),
- *Final Air Pathway RCRA Facility Investigation Report* (DOE 1997a), *and*
- *1997 RCRA Annual Hazardous Waste Report* (Energy Systems 1998*)*.

Preliminary results through November 1998 from the following additional studies, some of which have not been finalized, are included:

- sitewide human health risk assessment,
- various treatability studies,
- natural attenuation studies, and
- additional sampling of selected monitoring wells in Quadrant I.

These studies and documents meet the remedial investigation requirements of the Consent Decree and the AOC and provide data to accomplish the following:

- characterize the environmental setting, including groundwater, surface water, sediment, soil, and air;
- define and characterize sources of contamination;
- define and characterize the vertical and horizontal extent and degree of environmental

contamination;

- assess risk to human health and the environment resulting from possible exposure to contaminants; and
- provide information to support the CAS/CMS.

This report complies with the CAS and CMS requirements presented to DOE in the Consent Decree and the AOC as they pertain to Quadrant I. The Consent Decree requires a CAS that consists of the following elements:

- laboratory and bench-scale studies,
- development of alternatives,
- screening of alternatives,
- detailed analysis of alternatives,
- evaluation and selection of preferred alternative, and
- final report.

In addition, the AOC requires a CMS that includes the following elements:

- identification and development of corrective measure alternatives,
- laboratory and bench-scale studies,
- evaluation of corrective measure alternatives,
- justification and recommendation of corrective measures, and
- reports.

1.2 ORGANIZATION OF REPORT

The content of this CAS/CMS report was prepared according to the *Quadrant I CAS/CMS Work Plan* (DOE 1993), approved by the Ohio EPA and the U.S. EPA. Organizational changes have been incorporated in response to decisions reached by the PORTS Decision Team.

Chapter 1 presents a brief history of and current conditions at PORTS, describes applicable regulatory requirements and tasks prescribed by the AOC and Consent Decree, notes the purpose of the CAS/CMS report, and summarizes the Quadrant I RCRA Facility Investigative findings and conclusions.

Chapter 2 summarizes the PORTS Decision Team process and decisions made regarding Quadrant I SWMUs. This chapter also describes the Quadrant I SWMUs.

Chapter 3 describes the remedial action objective (RAO) development process, the U.S. EPA presumptive remediation strategy, and the general response actions and technologies to be considered in developing and evaluating remedial alternatives. This chapter also presents potential exposure pathways, contaminants of concern (COCs), and preliminary remediation goals (PRGs).

Chapter 4 briefly describes potential applications of treatability studies to the CAS/CMS process for Quadrant I. This chapter also presents descriptions of treatability studies conducted at PORTS.

Chapter 5 explains the process for development, analysis, and comparative evaluation of alternatives and criteria.

Chapter 6 presents the development, analysis, and comparative evaluation of alternatives for remediation of affected soils at the X-231A and X-231B oil biodegradation plots.

Chapter 7 presents the development, analysis, and comparative evaluation of alternatives for remediation of affected groundwater in the 5-Unit Groundwater Investigative Area.

Chapter 8 presents the development, analysis, and comparative evaluation of alternatives for remediation of affected groundwater for the X-749/X-120 Area.

Appendix A contains a summary of all Quadrant I constituent detections and their locations.

Appendix B contains a list of applicable, and relevant and appropriate, federal and state regulatory criteria.

Appendix C contains a summary of Quadrant I constituents that exceed the PRG and their locations, an example risk calculation, and a table showing selected PRGs.

Appendix D contains the basis for cost estimates given for the remedial alternatives in Chapters 6, 7, and 8.

Appendix E contains a narrative and supporting documentation for groundwater and natural attenuation modeling.

Appendix F contains information about aerobic biodegradation.

1.3 DESCRIPTION OF CURRENT CONDITIONS

1.3.1 General Description

PORTS has operated continuously since January 1955. The principal process at PORTS is the separation of uranium isotopes by gaseous diffusion for ^{235}U enrichment. Support operations include the feed of material into and withdrawal of material from the primary enrichment process, water treatment for sanitary and cooling purposes, decontamination of equipment removed from the plant for maintenance or replacement, recovery of uranium from various waste products, and treatment of sewage and cooling water blowdown. Construction, operation, and maintenance activities generate low-level (radioactive) waste (LLW), Toxic Substances Control Act (TSCA) regulated waste, RCRA waste, sanitary/industrial waste, and combinations of these waste types.

Quadrant I occupies the southern portion of the PORTS reservation (Figure 1.2). The boundaries of Quadrant I were established with respect to the surface water and groundwater flow and drainage patterns.

1.3.1.1 Physiographic setting of the PORTS facility

As shown in Figure 1.3, the PORTS facility is located within a mile-wide preglacial river valley situated 130 ft above the level of the Scioto River, which lies approximately 2 miles to the west. The facility lies within the Appalachian Plateau physiographic province approximately 20 miles south of the

Figure 1.3 Local Geography of the Ancient Portsmouth, Teays, and Newark Rivers limits of glaciation in Ohio (Feneman 1938). As a result, the topographic setting of the site has been heavily influenced by drainage associated with glacial events. The PORTS facility occupies an upland area of Southern Ohio with an average land surface elevation of 670 ft above mean sea level (msl). The naturally formed knolls and lowland areas of the immediate plant area were modified by grading and filling during plant construction. The terrain surrounding the plant site consists of farmland and wooded hills, with elevations generally less than 100 ft above the elevation of the facility.

Soil removal and filling operations within Perimeter Road performed during initial plant construction and during the Gas Centrifuge Enrichment Plant (GCEP) construction (early 1980s) resulted in elevations of 660 to 670 ft above msl. The lowest elevation in Quadrant I is approximately 570 ft above msl at the point at which the southwest access road crosses the DOE property boundary. The highest elevation (789 ft above msl) in Quadrant I is the top of a hill east of Perimeter Road.

1.3.1.2 Population distribution

The PORTS facility is located in east central Pike County, Ohio. The population of Pike County is approximately 24,250 (Energy Systems 1997a). Scattered farms and rural developments are typical in the county. The community of Piketon, approximately 5 miles north of PORTS on U.S. Route 23, is the nearest residential area and had a population of 1,717 in 1990. Other small villages near the facility include Wakefield and Jasper. Waverly, the county's largest community, is located 10 miles north of the facility and has a population of about 4,500.

1.3.1.3 Meteorology

The PORTS facility is located in the temperate zone of North America and has weather conditions that vary greatly throughout the year. The mean annual temperature is about 55EF. Summer and winter average temperatures are 72EF and 32EF, respectively. Record high and low temperatures are 103EF and -25EF, respectively.

Prevailing winds are out of the south-southwest and average 5 mph. The highest monthly average wind speed (11 mph) typically occurs in the spring (Energy Systems 1993).

Total annual precipitation averages approximately 40 in. The precipitation is usually well distributed. Fall is the driest season.

Snowfall averages approximately 20.4 in./year. Although snow amounts and frequencies vary greatly from year to year, an average 8 days/year have greater than 1 in. of snowfall.

1.3.1.4 Ecology

Threatened or Endangered Species. To date, no federally designated endangered or threatened species have been observed at PORTS, although several have ranges that could include PORTS and the surrounding vicinity. In June and August 1996, a survey for the Indiana bat (listed on both the state and federal endangered species lists) was conducted on the PORTS reservation. No Indiana bats were collected during the survey (DOE 1997b). One bird species endangered in Ohio, the sharp-shinned hawk (*Accipiter stratus*), has been observed at PORTS in the past although no habitat considered suitable for this species is present on the reservation. One special-interest fauna species, the rough green snake (*Opheodrys aestivus*), was observed in Quadrant IV. Ohio flora species reported at PORTS (Adams 1994 and DOE 1996b) include two potentially threatened species, blackjack oak (*Quercus marilandica*) and Virginia meadow-beauty (*Rhexia virginica*). An endangered species, Carolina yellow-eyed grass (*Xyris*, *difformis*), was observed in Quadrant II. One potentially threatened plant species, Rock skullcap (*Scutellaria saxatilis*), had been observed previously in Quadrant IV; however, it was not observed during the 1994 survey (Energy Systems 1997b). No Ohio threatened or endangered species were found in Quadrants I or III.

Ecological Communities. Ecologically, PORTS can be classified into terrestrial (land-based), wetland, and aquatic (water-based) communities.

<u>Terrestrial Communities</u> Forest-type communities consist of deciduous [northern red oak (*Quercus Rubra*), shagbark hickory (*Carya Ovata*), ash (*Fraxinus* sp.), maple (*Acer* sp.), etc.], and coniferous [Virginia pine, white pine, Scotch pine (*Pinus* sp.), etc.] trees. Vegetation includes scrub thickets, pasture land, and small wetland areas around ditches and holding ponds. Grounds inside Perimeter Road are generally maintained as lawns or mowed fields.

The terrestrial fauna community consists of mammals, birds, reptiles/amphibians, and insects. Twenty-two mammal species have been identified at PORTS, including white-tailed deer (*Odocoileus virginianus*), eastern cottontail rabbit (*Sylvilagus floridans*), gray fox (*Urocyon cinereoargenteus*), red fox (*Valpes vulpes*), and gray squirrel (*S. carolinensis*). The 116 species of birds that have been seen include raptors [red-tailed hawk (*Buteo tamaicensis*)], water birds [mallard (*Anas platyrynchos*) and wood ducks (*Aix sponsa*)], game field birds [ruffled grouse (*Bonassa umbellus*) and wild turkey (*Meleagris gallopauo*)], and nongame field birds [woodpecker (*Colaptes aurantus*) and nuthatch (*Sitta* sp.)].

Twenty-eight species of reptiles and thirty species of amphibians have habitat within PORTS. Common reptile species observed are turtles [midland painted (*Chrysemys picta*) and snapping (*Chelydra serpentina*)] and snakes [eastern garter (*Genus thamnophis*) and northern water (*Nerodia sipeden*)].

Amphibians commonly seen at PORTS are the northern dusky salamander (*Desmognathus fuscus*) and several species of frogs. The most common insect taxa at PORTS are Homoptera (cicadas and aphids), Hymenoptera (bees, wasps, and ants), Diptera (flies), Coleoptera (beetles), and Orthoptera (grasshoppers) (Energy Systems 1993).

Wetlands Before construction and development of PORTS, the area was heavily farmed. The initial industrial development of the area altered the landscape and in many areas removed the topsoil, thereby exposing the underlying clay subsoils. Subsequent development of landfills and construction spoils areas has disturbed surface drainage and resulted in poorly drained soils and areas of ponded water.

According to the sitewide wetland survey performed in October 1995 (Energy Systems 1996), 13 jurisdictional wetlands exist in Quadrant I (Figure 1.4). Table 1.1 describes the status, acreage, and location of wetlands in Quadrant I. No data exists indicating there are contaminants from the groundwater contaminant plumes entering the wetland areas.

Table 1.1 Status, Acreage, and Location of Wetlands in Quadrant I

Wetland ID #	Status	Acreage	Location	Comments
Q1-01	Jurisdictional	0.328	W. Perimeter Rd. ditch	Hillside seep
Q1-02	Jurisdictional	1.077	W. Perimeter Rd. ditch	Hillside seep
Q1-03	Jurisdictional	1.922	W. Perimeter Rd. ditch	Roadside ditch
Q1-05	Jurisdictional	0.259	X-2207 parking	Drainage ditch
Q1-06	Jurisdictional	0.230	X-749A Landfill	Drainage ditch
Q1-32	Jurisdictional	3.189	former GCEP site	Wet field
Q1-33	Jurisdictional	0.029	W. Perimeter Rd. ditch	Roadside ditch
Q1-34	Jurisdictional	0.269	former GCEP site	Wet field
Q1-35	Jurisdictional	0.374	former GCEP site	Wet field
Q1-36	Jurisdictional	0.125	former GCEP site	Wet field
Q1-37	Jurisdictional	4.626	former GCEP site	Wet field
Q1-38	Jurisdictional	0.254	former GCEP site	Wet field
Q1-39	Jurisdictional	0.228	former GCEP site	Wet field

Figure 1.4 Quadrant I Wetlands Map

Aquatic Communities Aquatic features include drainage ditches, holding ponds, and creeks on and near PORTS. Major types of aquatic organisms are periphyton (algae), macrophytes (aquatic plants), and benthic macro invertebrates (aquatic insects). Fifty-eight species of fish have been identified. Twenty-two of these species were found at three locations (two on Little Beaver Creek and one on Big Run Creek) downstream from the plant. Areas sampled in previous aquatic studies include Little Beaver Creek, Big Beaver Creek, Big Run Creek, West Drainage Ditch, and the Scioto River (Energy Systems 1997b).

1.3.1.5 Air quality

Ambient air quality at PORTS is influenced by active industrial processes and by remediation activities. According to the Air Permit Status Reports for 1997, the Ohio EPA has issued Permits to Operate (PTOs) for 13 DOE sources, 8 of which are being appealed, and for 62 USEC sources. Registration status has been issued for 9 DOE sources and 90 USEC sources. Four DOE sources have regulatory exemptions from permitting. USEC has 85 exempt sources. All DOE sources are considered minor for air pollutants. USEC has both major and minor sources and will be required to obtain a Title V permit (the Title V application was submitted September 1996 by USEC). The final comment responses to the *Final Air Pathway RCRA Facility Investigation Report* (DOE 1997a) were submitted to the Ohio EPA and the U.S. EPA on July 31, 1997; the document was subsequently approved by Ohio EPA and U.S. EPA on August 29, 1997 and August 12, 1997, respectively.

1.3.1.6 Noise

Noise at PORTS is intermittent and intensity levels vary. Noise levels associated with construction and processing activities are comparable to those of any other industrial site. On the basis of the distance from PORTS to the nearest residential area (Piketon), noise is not considered a problem.

1.3.1.7 Prior land use—archeological and historical

Historical Adena and Hopewell Indian Mounds exist in the PORTS region. Several historical American Indian tribes lived in nearby villages. No prehistoric sites have been documented within the DOE Facility property boundary. Before plant construction, the PORTS area included farmsteads, churches, schools, and cemeteries. In September 1996 and April-May 1997, Archaeological Services Consultants Group, Inc. (ASC Group, Inc.) conducted a Phase I literature review, archaeological reconnaissance survey, predictive model, and architectural survey at PORTS. Fourteen sites are considered potentially eligible for National Register of Historic Places status (ASC Group, Inc. 1997). Five of the 14 sites are located in

Quadrant I. These five sites are the Davis farmstead, South Shyville farmstead, Iron Wheel farmstead, and Beaver Road farmstead and a site where prehistoric litter was found. None of these sites will be impacted by remediation activities in Quadrant I.

1.3.2 Site Hydrology

Creeks, drainage ditches, and holding ponds are the prominent surface water features at PORTS. Sources of surface water drainage include precipitation runoff, groundwater discharge, and effluent from plant processes. All surface water eventually drains into the Scioto River, which flows south to the Ohio River. Little Beaver Creek and Big Run Creek provide drainage for a large portion of PORTS (Figure 1.5). The primary surface drainage in Quadrant I is Big Run Creek. The southwestern portion of Quadrant I is drained by the unnamed Southwest Drainage Ditch.

1.3.2.1 Creeks

Little Beaver Creek enters the PORTS reservation north of the east access road. The creek flows north-northwest, was diverted to the eastern side of the X-611A Sludge Lagoons when the lagoons were constructed, and then flows west until it exits DOE property. The east, northeast, and north drainage ditches discharge to Little Beaver Creek within the property boundary. Little Beaver Creek converges with Big Beaver Creek approximately 1.5 miles northwest of the plant. Big Beaver Creek continues southwest 1.5 miles, where it discharges into the Scioto River. Little Beaver Creek drains the entire northern and eastern portions of PORTS; flow is moderate and during parts of the year consists primarily of plant effluent through the plant stormwater system.

Big Run Creek begins at the X-230K South Holding Pond in the southeastern portion of PORTS and flows south to the DOE property boundary. Big Run Creek continues southwest until it discharges into the Scioto River, approximately 4 miles southwest of the plant site. Big Run Creek drains the southeastern area of PORTS; flow within the waterway is usually low. The main water supplies to Big Run Creek are groundwater discharge, stormwater runoff, and some effluent from plant processes through the X-230K South Holding Pond.

Figure 1.5 Surface Water Drainage and NPDES Outfalls at PORTS

Both Little Beaver and Big Run Creeks currently flow throughout the year with a significant portion of the flow provided by water discharge from PORTS facilities. Pre-PORTS hydrologic studies performed by the U.S. Geological Survey documented that both of these streams were intermittent with little or no flow during the months of August, September, and October.

Two ditches drain the western and southwestern portions of the site; flow is low to intermittent. The West Drainage Ditch receives water from surface water runoff, storm sewers, and plant effluent. The unnamed Southwest Drainage Ditch receives water mainly from storm sewers and groundwater discharge. These two drainages continue west and ultimately discharge into the Scioto River.

Most surface runoff, stormwater, and groundwater in Quadrant I drains through Big Run Creek and the unnamed Southwest Drainage Ditch.

1.3.2.2 Holding ponds

Holding ponds are used as quiescent zones to control plant process effluent. The ponds lower peak flow and increase the duration of runoff from storm events. The ponds also promote chlorine dissipation and settling of sediment mobilized by stormwater runoff. Many also serve as spill retention basins to prevent off-site migration of spills or accidental discharges until treatment or recovery can be accomplished. Several ponds were designed specifically to treat process effluent. For example, the X-611B Sludge Lagoon is used for deposition of lime sludge generated from the drinking water purification process. Table 1.2 summarizes all the holding ponds on-site, their respective uses, and the drainage courses into which they drain. Two holding ponds are located in Quadrant I (X-230K and X-2230M). Both are used to control stormwater runoff and to capture sediment (Figure 1.5).

1.3.2.3 Surface water monitoring

Surface water monitoring of permitted outfalls and routine voluntary sampling is conducted at PORTS both on- and off-site. Routine and permitted outfall samples are tested for various parameters including radiological components (gross alpha, gross beta-gamma, technetium, and uranium), pH, flow, turbidity, trichloroethene (TCE), oil and grease, heavy metals, fluorides, phosphates, and PCBs.

Table 1.2. Summary of Holding Ponds, Portsmouth Gaseous Diffusion Plant, Piketon, Ohio

Pond	Location (Quadrant)	Purpose/Use	Discharges To
X-230J5	West (III)	Control stormwater runoff/sedimentation	Scioto River
X-230J6	Northeast (IV)	Control stormwater runoff/sedimentation	Little Beaver Creek
X-230J7	East (II)	Control stormwater runoff/sedimentation	Little Beaver Creek
X-230K	**Southeast (I)**	**Control stormwater runoff/coal pile steam plant discharge**	**Big Run Creek**
X-230L	North (IV)	Spill retention/control storm runoff/sedimentation	Little Beaver Creek
X-611A*	Northeast (IV)	Lime sludge lagoons (3), water treatment effluent	Little Beaver Creek
X-611B	Northeast (IV)	Lime sludge lagoon, water treatment effluent	Little Beaver Creek
X-701B	East (II)	Treatment of effluent	East Drainage Ditch
X-2230M	**Southwest (I)**	**Control stormwater runoff/sedimentation from GCEP ****	**Scioto River**
X-2230N	West (III)	Control sedimentation from GCEP construction	Scioto River

* Converted to a prairie habitat.
**GCEP = gaseous centrifuge enrichment process

Most surface water sampling at PORTS is mandated by the National Pollutant Discharge Elimination System (NPDES) permit system enforced by the Ohio EPA. NPDES permit limitations regulate all plant effluent discharged to the environment. In September 1995, DOE and USEC were issued separate NPDES permits. There are six DOE outfalls (three discharge directly to surface water), and eleven USEC outfalls (eight discharge directly to surface water). In Quadrant I, DOE and USEC each have one internal and one external outfall (see bolded items below and Figure 1.5).

External NPDES Outfalls:

001 X-230J7 Holding Pond (USEC)
002 X-230K South Holding Pond (USEC)
003 X-6619 Sewage Treatment Plant (USEC)
004 X-616 Chromate Treatment Plant (USEC)
005 X-611B Sludge Lagoon (USEC)
009 X-230L North Holding Pond (USEC)
010 X-230J5 Holding Pond (USEC)
011 X-230J6 Holding Pond (USEC)

012 X-2230M Holding Pond (DOE)

013 X-2230N Holding Pond (DOE)
015 X-624 Groundwater Treatment Facility (DOE)

Internal NPDES Outfalls:
602 X-621 Coal Pile Treatment Facility (USEC)
604 X-700 Biodenitrification Facility (USEC)
605 X-705 Microfiltration Facility (USEC)
608 X-622 Groundwater Treatment Facility (DOE)
610 X-623 Groundwater Treatment Facility (DOE)
611 X-622T Groundwater Treatment Facility (DOE)

DOE conducts additional surface water sampling at PORTS to monitor effluent for possible releases to the environment. Surface water monitoring of the Big Run Creek, East Drainage Ditch, Little Beaver Creek, North Holding Pond, unnamed Southwest Drainage Ditch, and West Drainage Ditch is conducted quarterly to assess the effect of the discharge of groundwater to streams (as base flow) at PORTS. This monitoring helps to support assessment monitoring at X-231B and X-701B, and post-closure monitoring at X-616, X-735, and X-749. These surface monitoring locations are part of the Groundwater Monitoring Program and are not considered part of the PORTS National Pollution Discharge Elimination System (NPDES) sampling program. Data collected at the stations facilitate comparison of the water quality upstream and downstream of groundwater contaminant plumes so that the effect of the plumes on the creeks can be isolated.

1.3.3 Site Geology

The geology of the PORTS facility has been characterized through the drilling of over 1,600 borings and wells throughout the site. The near-surface geologic materials that influence the hydrologic system at the PORTS facility consist of several bedrock formations and unconsolidated deposits. The bedrock formations (from oldest to youngest) are Bedford Shale, Berea Sandstone, Sunbury Shale, and Cuyahoga Shale. The unconsolidated deposits of clay, silt, sand, and gravel compose the Minford Clay and Silt (Minford) member and the Gallia Sand and Gravel (Gallia) member of the Teays formation (DOE 1996a). Before the Pleistocene glaciation, the Teays River and its tributaries were the dominant drainage system in Ohio. The Teays River originated in the Piedmont region of Virginia and North Carolina and entered Ohio from the south in Scioto County. The Teays River then flowed southeast to northwest and passed approximately 3 miles north of the location now occupied by the PORTS facility (Figure 1.6). In the vicinity of the PORTS facility, the location of the ancient Teays River Valley, currently occupied by Big

Beaver Creek, is easily visible on topographic maps. The preglacial Portsmouth River, a tributary of the Teays, flowed north across the plant site between bluffs of Cuyahoga Shale. The Portsmouth River cut down through the Cuyahoga Shale and into the Sunbury Shale and Berea Sandstone and deposited fluvial silt, sand, and gravel of the Gallia member of the Teays Formation (Figure 1.7).

Approximately one million years ago, a glacier advancing from the north blocked the northwestward flow of the Teays River. This blockage resulted in the creation of the regional Lake Tight, which occupied the valleys of the Teays River and its tributaries, including the Portsmouth River in the area now occupied by PORTS. Lacustrine silt and clay (Minford), indicative of low-energy conditions, were deposited on the lake bottom over the meandering Gallia stream deposits. The basal 10 to 15 ft of the Minford commonly consists of very fine sand and silt, which reflect shallow lake levels and reworked sediment of possibly Portsmouth River over-bank deposits. The silt progressively becomes more clayey and grades upward into a series of laminated clays that represent sediments deposited as glacial Lake Tight grew deeper and more extensive.

Although glacial damming occurred on drainage systems in North America during many of the glacial advances, the formation of Lake Tight and subsequent deposition of the Minford silt and clay in Southern Ohio appear to be the result of a single episode of damming the Teays River during a pre-Illinoian glacial advance (likely the Kansan advance) (Bonnett 1991, Goldthwait 1991).

Eventually, Lake Tight overflowed its banks and initiated the high-volume and high-energy, lower-elevation drainage paths known as Deep Stage drainage. The most significant Deep Stage stream in southern Ohio was the south-flowing Newark River. The Newark River occupied the former Teays River Valley from Chillicothe to Waverly, bypassed the area of the PORTS facility, and then occupied the former Portsmouth River Valley south to Portsmouth. As the glaciers retreated, meltwater flowed down the Newark River Valley and partially backfilled it with outwash. The present-day Scioto River flows to the south in the former Newark River Valley on top of a thick layer of outwash.

Figure 1.6 Ancient River and Glacial Deposits of Portsmouth, Teays, Newark and, River Systems

Figure 1.7 Schematic Block Diagram Showing Geology at PORTS

1.3.3.1 Bedrock geology

Mississippian-age clastic sedimentary rocks underlie the unconsolidated sediments beneath the PORTS facility (DOE 1996a, Appendix A, Plates III, IV, and V). The geologic structure of the area is very simple, with the Mississippian strata (Cuyahoga Shale, Sunbury Shale, Berea Sandstone, and Bedford Shale) dipping gently to the east-southeast at approximately 30 ft/mile. No known geologic faults are located in the area. Outcrops of thin sandstone interbeds in the Cuyahoga Shale and Bedford Shale show two distinct joint sets at N65EE and N25EW. Horizontal bedding-plane fractures are also present in the bedrock formations.

The Bedford Shale is the lowest stratigraphic unit encountered during environmental investigative activities at the site. The Bedford is composed of thinly bedded shale with interbeds and laminations of gray, fine-grained sandstone and siltstone. Sandstone interbeds predominate in the upper regions but decrease in frequency with depth. The typical depth to the top of this formation at the PORTS facility is 70 to 100 ft below ground surface. However, Bedford outcrops are present in deeply incised streams and valleys within the reservation. The Bedford averages 100 ft in thickness.

The Berea Sandstone is a light gray, thickly bedded, fine-grained sandstone with thin shale laminations. The top 10 to 15 ft consists of a massive sandstone bed with few joints or shale laminae. The Berea averages 35 ft in thickness; however, the lower 10 ft has numerous shale laminations and is very similar to the underlying Bedford Shale. This gradational contact does not allow for a precise determination of the thickness of the Berea. Regionally, the Berea contains naturally occurring hydrocarbons (oil and gas) in quantities sufficient for commercial production. Generally, within Perimeter Road, the Berea is the uppermost bedrock unit beneath the western portion of the PORTS facility but is overlain by the Sunbury Shale to the east.

The Sunbury Shale is a black, very carbonaceous shale. In outcrops, the Sunbury is fissile and highly fractured, but in cores obtained during bedrock drilling at the PORTS facility, the Sunbury has been found to be coherent. A thin (1- to 3-in.) zone of sulfide mineralization occurs locally at the contact between the Sunbury and the underlying Berea Sandstone. The Sunbury is 20 ft thick beneath much of the PORTS facility but thins westward as a result of erosion by the ancient Portsmouth River and is absent on the western half of the site. The Sunbury is also absent in the drainage of Little Beaver Creek downstream of the X-611A and the southern portion of Big Run Creek, where it has been removed by erosion. The Sunbury underlies the unconsolidated Gallia beneath the most industrialized eastern portion of the plant and underlies the Cuyahoga Shale outside of the Portsmouth River Valley. The Sunbury Shale is present beneath the unconsolidated sediments in Quadrant I, except small portions in the northwestern parts of the quadrant, the unnamed

Southwest Drainage Ditch, and Big Run Creek.

The Cuyahoga Shale, the youngest and uppermost bedrock unit at the site, forms the hills surrounding PORTS. The Cuyahoga Shale has been eroded from most of the active portion of the PORTS facility. It consists of gray, thinly bedded shale with scattered lenses of fine-grained sandstone and regionally reaches a thickness of approximately 160 ft.

1.3.3.2 Unconsolidated deposits

Unconsolidated deposits in the vicinity of the PORTS facility fill the ancient Portsmouth River Valley to depths of approximately 30 to 40 ft. The unconsolidated deposits are divided into two members of the Teays Formation: the Minford Clay and Silt and the Gallia Sand and Gravel.

Minford Clay and Silt. The Minford is the uppermost stratigraphic unit beneath the PORTS facility. The Minford averages 20 to 30 ft in thickness and grades from predominantly silt and very fine sand at its base to clay near the surface. The upper clay unit averages 16 ft in thickness, is reddish-brown, plastic, and silty, and contains traces of sand and fine gravel in some locations. These thicknesses vary greatly as a result of construction-related cutting and filling operations, as discussed in the next paragraph. The lower silt unit averages 7 ft in thickness, is yellow-brown and semiplastic, and contains varying amounts of clay and very fine sand. The contact between silt and clay is gradational. A study by Law Engineering Testing Company (1978) estimated silt content in the Minford as a whole to be approximately 33 percent.

During the initial grading of the site, the deposits within Perimeter Road were reworked to a depth as great as 20 ft by preconstruction cut and fill activities. Figure 1.8 was constructed by comparing preconstruction topography with circa 1995 topography and shows areas where fill material has been placed. In most cases, the fill is indistinguishable from the undisturbed Minford.

Figure 1.8 Areas of Minford Cut and Fill from Construction Activities

In summary, the combination of construction activities, bedrock topography, and erosion by modern streams has influenced the areal extent and thickness of the Minford at the PORTS facility. In Quadrant I, the Minford/fill material reaches thicknesses of 30 ft.

Gallia Sand and Gravel. Before the Pleistocene glaciation, the Portsmouth River meandered north through the valley currently occupied by the PORTS facility and deposited the sand and gravel of the Gallia. The Gallia averages 3 to 4 ft in thickness at the site and is characterized by poorly sorted sand and gravel with silt and clay. Law Engineering Testing Company (1978) indicated that the average clay content of the Gallia is 30 percent. Studies conducted in the X-749/X-120 Area in 1995 described three textural facies (sand, gravelly sand, and a gravelly mixture) associated with the Gallia and lower Minford (DOE 1996d). The sand unit is composed of very fine sand and silt and may represent overbank deposits/levees and upper point bar deposits that were reworked and partially redistributed during the formation of Lake Tight. The gravelly sand unit likely represents a mixture of channel lag and lower point bar deposits. The gravelly mixture unit occurs predominantly near channels of former or active streams. Channel migration and variation in depositional environments that occurred during deposition of the Gallia resulted in the variable thickness of the Gallia. The areas of thickest accumulation of the Gallia may represent the channel location just before the formation of Lake Tight. The ancient channel extends from the south near Big Run Creek northward along the eastern side of the valley and then curves to the west under the southern end of the X-330 Process Building and continues north along the western side of the valley. An earlier meander valley of the Portsmouth River was cut through the Cuyahoga Shale east of the site. Thick Gallia deposits are present where this secondary meander valley intersects the main valley near the X-701B Holding Pond. Remnants of sandy point bar deposits along such channels created localized zones of high permeability in the Gallia. Valley walls of the ancient Portsmouth River formed a natural barrier for deposition of Gallia channel deposits. Gallia deposits beneath PORTS are generally absent above an approximate elevation of 650 ft above msl.

1.3.3.3 Surface soil description

According to the Soil Survey of Pike County, Ohio (USDA 1990), the predominant soil type at PORTS is Omulga Silt Loam. Most of the area within the active portion of PORTS is classified as Urban Land-Omulga complex with a 0 to 6 percent slope, which consists of Urban Land and a deep, nearly level, gently sloping, moderately well-drained Omulga soil in preglacial valleys. The Urban Land is covered by roads, parking lots, buildings, and railroads that so obscure or alter the soil that identification of the soil series is not feasible.

The surface layer of Omulga Silt Loam is dark grayish-brown, friable (easily crumbled), and approximately 10 in. thick. The subsoil is approximately 54 in. thick and is composed of three portions: (1) a yellowish-brown, friable silt loam; (2) a fragipan (brittle, compacted subsurface soil) of yellowish-brown, mottled, firm, and brittle silty clay loam middle; and (3) a yellowish-brown, mottled, friable silt loam approximately 20 in. thick. The root zone is generally restricted to the zone above the fragipan and contains none of the Urban Land soils. Well-developed soil horizons may not be present in all areas inside Perimeter Road because of cut-and-fill operations related to construction.

Geologic cross section are presented illustrating the geologic conditions for the 5-Unit Groundwater Investigative Area (Figures 1.9 and 1.10) and the X-749/X-120 area groundwater plume (Figures 1.11 and 1.12).

1.3.4 Site Hydrogeology

The groundwater flow system at the PORTS facility includes two water-bearing units (the bedrock Berea Sandstone and the unconsolidated Gallia) and two aquitards (the Sunbury Shale and the unconsolidated Minford). The basal portion of the Minford is generally grouped with the Gallia to form the uppermost and primary water-bearing unit at the facility. As discussed in the following paragraphs, the hydraulic properties of these units have been well defined during previous investigations at the facility. Groundwater flow at the site also has been well defined.

1.3.4.1 Hydrologic properties

Several single-well aquifer tests were performed by Geraghty & Miller (Geraghty & Miller, Inc. 1989) at the PORTS facility to estimate the hydraulic conductivity of the Berea Sandstone (the lowest water-bearing unit). Measured hydraulic conductivity values of the Berea Sandstone range from 4.5×10^{-3} to 15 ft/d, with a mean value of 0.16 ft/d. The arithmetic mean of hydraulic conductivity measurements in the Berea Sandstone at the X-616 Effluent Treatment Facility (where the Sunbury Shale is absent and the Berea Sandstone may be eroded and weathered) is 0.35 ft/d. The general range for hydraulic conductivity of sandstones is 3.0×10^{-5} to 30 ft/d (deMarsily 1986). Although two joint sets have been measured in thinly bedded sandstone layers at the PORTS facility, significant secondary permeability in the upper massive sandstone bed of the Berea was not noted in previous investigations.

Figure 1.9 5-Unit Investigative Area Geological Cross Section A to A’

Figure 1.10 5-Unit Investigative Area Geological Cross Section B to B’

Figure 1.11 X-749/X-120 Area Geological Cross Section A to A’

Figure 1.12 X-749/X-120 Area Geological Cross

The hydraulic conductivity of the Gallia, as determined by single-well tests across the entire PORTS facility, varies from 0.11 to 150 ft/d with an arithmetic mean value of 3.4 ft/d. A hydraulic conductivity for the Gallia of 1.8 ft/d was determined from a short-term test performed by Geraghty & Miller (1989) in the vicinity of the X-749 unit.

Multiple-well aquifer tests were performed at the X-701B Holding Pond (Quadrant II) and the X-231 Biodegradation Plot (Quadrant I) by Geraghty & Miller (1990a, 1991) to estimate hydraulic properties of the Gallia. On the basis of an average thickness of 5 ft, estimated hydraulic conductivity values in the Gallia range from 24 to 104 ft/d at the X-701B Holding Pond, with arithmetic mean and median values of 49 ft/d and 44 ft/d, respectively. The X-231B Biodegradation Plot test yielded values between 6.8 and 62 ft/d, with an arithmetic mean and median of 38 ft/d and 40 ft/d, respectively.

Slug tests were also performed as part of recent field investigations carried out at the X-749/X-120 area. The hydraulic conductivity of the Gallia ranged from 1.9 to 8.1 ft/d in the southern part of the X-749 plume (HAZWRAP 1993). The hydraulic conductivity of the Gallia is generally higher in thicker areas. The storage coefficient for the Gallia also varies considerably at the facility: the range is from 0.00011 to 0.41, with an arithmetic mean of 0.16 (Geraghty & Miller, Inc. 1989).

Numerous laboratory measurements of hydraulic conductivity for the Minford clay and silt units were performed by Law Engineering Testing Company (1982). The average measured permeability of the Minford clay is 2.3×10^{-4} ft/d and the average measured permeability of the Minford silt is 4.3×10^{-3} ft/d. Laboratory analyses of two Minford silt and clay cores collected in the X-701B area (Quadrant II) by Geraghty & Miller (1992a) yielded vertical hydraulic conductivity estimates of 2.6×10^{-5} ft/d and 1.3×10^{-4} ft/d. Geraghty & Miller (1989) performed a single-well aquifer test in the Minford at the X-616 unit (Quadrant III) that yielded a hydraulic conductivity value of 0.62 ft/d. On the basis of these low hydraulic conductivity values, the Minford clay is considered to be an effective aquitard.

1.3.4.2 Groundwater recharge and discharge areas

Groundwater recharge and discharge areas at the PORTS facility include both natural and man-made recharge and discharge areas. Both types are discussed in the following sections.

Natural Recharge and Discharge Areas. Natural recharge to the groundwater flow system at the PORTS facility comes from precipitation. Net recharge, the amount of water available for infiltration, has been previously estimated to range between 8.9 and 13.9 in./year by using the empirical Thorthwaite method (Geraghty & Miller, Inc. 1989, 1990a). These estimates ignored the large areas covered by roofed buildings, paved roads, or storage areas where precipitation is diverted directly to storm sewers, streams, or creeks draining the area. The Thorthwaite method also ignores the effects of transpiration by vegetation. Therefore, direct infiltration from precipitation is considerably less than that cited previously. The continuity and low permeability of the Minford formation, especially the uppermost clay unit, also reduces infiltration into the groundwater flow system. On the basis of the calibration calculations performed during groundwater modeling for the 5-Unit Groundwater Investigative Area and X-749/X-120 Area, recharge could be as low as 2 to 4 in./year, the average for this part of Ohio (Pettyjohn and Henning 1979).

Land use and the presence of thick upper Minford clay deposits and the presence of Sunbury Shale effectively reduce recharge to underlying units. On the northern portions of Quadrant I, recharge to the Minford and Gallia is reduced because a large percentage of the land is paved or covered by buildings. The bedrock valley walls boarding the eastern portion of Quadrant I are composed of shale and, therefore, contribute little groundwater recharge to the area.

Discharge of groundwater to the surface occurs primarily along streams that transect the PORTS facility. Groundwater in the eastern and northern portions of the facility discharges to the East and North Drainage Ditches and to Little Beaver Creek. Along the western boundary of the site, the West Drainage Ditch serves as a local discharge area for all geologic units. In Quadrant I, groundwater discharges to Big Run Creek and to the unnamed Southwest Drainage Ditch.

Effects of Utility Systems on Groundwater Flow. Groundwater recharge and discharge areas at the PORTS facility may also be affected by building sumps and numerous utility systems: the storm sewer system, the sanitary sewer system, the recirculating cooling water system, and water lines. The storm sewer system consists of numerous large-diameter culverts and pipes that drain surface water from discrete segments of the site. The storm sewer system, including its associated backfill, may intercept groundwater in the Minford and, in certain areas, in the Gallia. Discharge points for the storm drains generally coincide with site NPDES outfalls that eventually discharge to the surface water units described previously. Review of groundwater flow data suggests that utilities do not have a significant effect on groundwater flow in the Gallia.

Three other systems of underground lines that could affect groundwater flow at the PORTS facility are the recirculating cooling water system, the sanitary sewer system, and water supply lines. These systems are generally located within 6 to 12 ft of the ground surface. The depth to groundwater is generally greater than 12 ft below ground surface in Quadrant I. Consequently, these systems and their associated backfills are usually located above the local water table. On the basis of these factors, none of these systems appears to significantly affect groundwater flow. The recirculating cooling water and fire hydrant supply systems are pressurized to ensure proper transport of water. If these systems have leaks, they may have the potential to act as sources of recharge to groundwater. There is currently no evidence that these systems are affecting groundwater flow.

1.3.4.3 Groundwater flow

Groundwater flow at PORTS can generally be divided into four separate flow regions, or quadrants. Groundwater divides provide the basis for separation of the reservation into quadrants. The groundwater divides generally coincide with topographic highs along the center of the industrial complex (from south to north) and topographic highs radiating outward and separating the predominant surface water features draining the facility. The locations of the groundwater flow divides may migrate small distances in response to seasonal changes in precipitation and groundwater recharge.

The directions of groundwater flow and gradients at the PORTS facility are determined by recharge, interactions within and between hydrogeologic units, natural surface drainages, and the man-made features discussed previously. Of all the variables, surface water drainage at the site has the greatest influence. The horizontal directions of groundwater flow in the Gallia and Berea are similar across the site (DOE 1996a; Plate VIII and IX). Groundwater flow in both of these units is strongly influenced by Little Beaver Creek, Big Run Creek, the West Drainage Ditch, and the unnamed Southwest Drainage Ditch. Groundwater in the Gallia, in each flow region, ultimately discharges to a surface water drainage. In general, groundwater gradients are flatter in the upland areas, in the center of the industrial complex, and become steeper as groundwater approaches the streams or creeks. Vertical movement of groundwater between the Gallia and Berea is both upward and downward across the site. In general, downward movement is observed in upland areas of recharge and upward movement is noted in areas of discharge near streams.

Throughout most of Quadrant I, the Berea and Gallia water bearing zones are separated by the Sunbury Shale. Based on its composition, the Sunbury Shale is considered an aquitard in the local groundwater system. The vertical hydraulic gradient between the Gallia and Berea decreases to the west as the Sunbury thins.

Groundwater flow directions in the Berea in Quadrant I are generally toward the south-southeast except in the areas where Big Run Creek and the unnamed Southwest Drainage Ditch intersect the Berea sandstone. The north-south groundwater divide occurs farther west in the Berea than in the Gallia, with flow to the east toward Big Run Creek and to the west towards the unnamed Southwest Drainage Ditch.

Groundwater flow in the 5-Unit Groundwater Investigative Area is influenced by the presence of surface drainages, storm drains, bedrock topography, buildings, paved areas, and the thickness of the clay portion of the Minford. In general, groundwater in the Gallia flows from north to south, discharging into Big Run Creek (DOE 1996a, Plate VIII, Appendix A). Groundwater in the Gallia in the south central portion of the site (near X-231B) flows primarily to the southeast toward the X-230K Holding Pond (Figure 1.13). The hydraulic gradient is very low because of the flat valley floor; the presence of thicker, more permeable Gallia deposits; and the proximity to the east-west groundwater divide that runs through the facility.

The most significant man-made discharge influence in the immediate vicinity of the 5-Unit Groundwater Investigative Area is groundwater pumpage from extraction wells B-10, B-11, and B-12. These wells pump at an average combined rate of 25,000 gpd and locally capture contaminated groundwater that is migrating from the 5-Unit Groundwater Investigative Area toward the X-230K Holding Pond. Contaminated groundwater is diverted from the east and west toward the extraction wells for a width of about 500 to 800 ft depending on the amounts of recent recharge and the rates of pumpage from the extraction wells.

Annual groundwater level fluctuations of approximately 1 ft to 3 ft were measured in Gallia formation wells located in areas of higher land surface elevation (i.e., X231A-14G and X231B-04G), while annual fluctuations of approximately 1 ft or less were measured in wells located in the lower land surface elevation (i.e., X231B-37G). However, larger fluctuations were measured in the monitoring wells located in the area influenced by the extraction wells. The initiation of pumping and the increase in the pumping rate during 1990 and 1991 coincide with a head reduction of approximately 5 ft in nearby wells
Figure 1.13 5-Unit Groundwater Investigative Area Potentiometric Surface Map for the Gallia Sand and Gravel

(i.e., X231B-15G and X231B-23G). This head reduction demonstrates the effect of the groundwater extraction activities.

Groundwater flow velocity in the Gallia calculated for the X-231B area for the fourth quarter of 1997 is toward the south/southeast at 2.0 ft/day. The Berea groundwater flow direction is similar to that of the overlying Gallia except that its gradient slopes more uniformly to the south/southeast. The hydraulic gradient for the Berea shows negligible seasonal variation and is consistently 0.007 ft with a representative groundwater velocity in the Berea sandstone of less than 0.1 ft/day (DOE 1998).

In the X-749/X-120 Area, a groundwater divide that trends approximately north-south exists west of the X-749 unit (DOE 1998), (Figure 1.14). On the west side of this divide, flow is to the southwest towards the unnamed Southwest Drainage Ditch. In addition, a cone of depression in the potentiometric surface has developed over the screened portion of the X-120 horizontal well. Groundwater flow on the east side of this divide, and east of the X-749 landfill, has a steep eastward gradient in the direction of Big Run Creek. It is unlikely, however, that any significant amount of groundwater actually discharges to Big Run Creek east of X-749 due to thin or absent Gallia deposits near the creek. South of the X-749 landfill the preferred direction for groundwater movement is to the south-southwest through the thicker Gallia deposits (as evidenced by the current location of the contaminant plume). A bedrock high located south of the southern edge of the plant site causes groundwater to flow in an east-west direction in this area.

The most significant man-made discharge influence in the vicinity of the X-749/X-120 Area is extraction of groundwater from the X-749 Landfill east and west interceptor trenches, the Peter Kiewit leachate collection system, and the X-120 horizontal well. Flow is also affected by the X-749 cap and slurry walls, and the containment wall near the southern property boundary.

Annual groundwater level fluctuations of approximately 2 ft to 6 ft were measured in Gallia formation wells located in the central portion of the X-749/X-120 area (i.e., X749-25G and X749-32G), while annual fluctuations of approximately 1 ft to 2 ft were measured in wells located in the western portion of the area (i.e., X749-59G).

Figure 1.14 X-749/X-120 Area Potentiometric Surface Map for the Gallia Sand and Gravel

Groundwater flow velocities in the Gallia calculated for the X-749/X-120 area for the fourth quarter of 1997 are 1.0 ft/day in the east, 0.1 ft/day in the west, and 0.5 ft/day in the south. Groundwater flow direction and velocity in the Berea, based on fourth quarter water level measurements during 1997, is toward the east at 0.3 ft/day and toward the south at 0.2 ft/day (DOE 1998).

1.3.4.4 Groundwater monitoring

An assessment monitoring program was initiated in 1989 to monitor groundwater contamination associated with the four hazardous waste land disposal units. Groundwater at two additional RCRA hazardous waste units is also currently monitored. All wells in the program are sampled quarterly or semiannually and results are published in an annual report (DOE 1997b). Surface water samples are collected to monitor potential contaminant discharge from groundwater to surface water. The six RCRA hazardous waste units at PORTS sampled in 1997 and the total number of wells sampled at each unit are as follows:

- X-231B Oil Biodegradation Plot (Quadrant I), 15 wells sampled;
- X-701B Holding Pond (Quadrant II), 26 wells sampled;
- X-749 Contaminated Materials Disposal Facility (Quadrant I), 29 wells sampled;
- X-616 Chromium Sludge Surface Impoundments (Quadrant III), 15 wells sampled;
- X-701C Neutralization Pit (Quadrant II), 3 wells sampled; and
- X-735 Sanitary Landfill (Quadrant IV), 13 wells sampled.

In addition, six wells associated with the X-611A Sludge Lagoons in Quadrant IV are currently sampled semi-annually per the operation and maintenance plan that was prepared as part of the X-611A Sludge Lagoons CMI.

An Integrated Groundwater Monitoring Plan (IGWMP) has been developed to consolidate hazardous waste, solid waste, and corrective action monitoring into a single plan. Section 2.1.4 contains a further discussion of groundwater monitoring.

1.3.5 Waste Management, Construction, and Response Actions

1.3.5.1 Waste management

DOE generates and manages the following general categories of wastes: (1) LLW, (2) TSCA-regulated wastes, (3) hazardous wastes, and (4) sanitary/industrial wastes. DOE also generates and manages combinations of LLW, TSCA, and RCRA wastes. Waste is managed as radioactive unless unrestricted release criteria are met. Unrestricted release is currently limited to materials for which bulk contamination is not a possibility (e.g., sheet steel or intact aerosol cans) or, in a few cases, where the area of generation has been characterized as "clean."

Permitted storage facilities are available for all waste types that may be generated as a result of DOE operations, emergency response actions, construction activities, and remedial actions. On-site NPDES-permitted wastewater treatment facilities are available for the treatment of aqueous wastes. DOE has an active waste management program to implement new treatment or disposal options as they become available.

1.3.5.2 Construction activities

Since December 1990, several major construction activities have occurred at PORTS. Most activities were related to environmental restoration projects at the plant. The following list includes activities conducted in Quadrant I.

X-231A Southeast Oil Biodegradation Plot. This plot was originally treated with agricultural lime and fertilizer, which were disced into the soil. A soil berm was later added along with a reinforced geosynthetic membrane cover. In 1996 and 1997, several treatability studies were performed at the site.

X-231B Southwest Oil Biodegradation Plot. In July 1994, implementation of interim remedial measures (IRMs) at X-231B was completed. These measures consisted of shallow soil mixing (SSM) to a depth of approximately 22 ft below ground surface combined with thermally enhanced vapor extraction (TEVE). The off-gases were treated through a series of activated carbon and High Efficiency Particulate Air (HEPA) filter units and 70 percent of the volatile organic compounds (VOCs) were removed. After treatment, the site was covered with a clean soil layer and graded to promote precipitation runoff.

Underground pipes from three groundwater extraction wells near X-231B were installed to deliver groundwater to the X-622 Groundwater Treatment Facility.

X-622 Groundwater Treatment Facility. The X-622 Facility became operational in April 1992. The carbon filtration unit removes VOCs from contaminated groundwater pumped from the X-231B and X-749 site remediation activities and the Peter Kiewit seep collection systems.

X-749 Contaminated Materials Disposal Facility (X-749 Landfill). A Closure Plan was approved in June 1989 for the closure of the X-749 landfill. A multimedia cap was installed over the northern (6.1 acres) and southern (2.25 acres) portions of the facility. Construction activities began in February 1991. The northern portion was completed in June 1992 and the southern (final portion) in December 1992. A slurry wall installed along the northern and western boundaries of the landfill restricts movement of groundwater into the landfill area. A groundwater collection system installed along the southwestern boundary and the northern portion of the eastern boundary of X-749 captures contaminated groundwater flow from the landfill. The captured groundwater is pumped to and treated at the X-622 Groundwater Treatment Facility.

X-749 IRM Containment Wall. In the spring of 1994, the Ohio EPA and U.S. EPA approved construction of a 1,077-ft long subsurface barrier wall near the southern DOE property line to prevent groundwater containing tricholoethene (TCE) from moving outside the PORTS boundary. Construction activities began in April 1994 and were completed in September 1994.

X-749A Classified Materials Burial Ground. In June 1989, DOE submitted a Closure Plan to close this landfill in compliance with U.S. EPA regulations for solid waste landfills. The Closure Plan was approved in April 1992. The remedial action was to cover the 5.9-acre landfill with a multimedia cap. Closure of the X-749A landfill began in June 1993 and was completed in April 1994.

X-749/X-120 Pilot Scale Treatment Project. Construction of the experimental facility began in June 1995. This project tests the effectiveness of various treatment media in removing VOCs from groundwater. The project also evaluates low-energy, passive-flow treatment applications. A horizontal well installed just above bedrock through the X-120 plume allowed groundwater to flow naturally into the testing facility (X-625). Operations at the testing facility began in March 1996.

X-750 Waste Oil Storage Tank. A 500-gal tank was installed in 1962 to collect waste oils from the X-750 building. The collection operation was stopped in 1990. In May 1992, DOE submitted a Closure Plan to remove the tank and all associated contaminated materials. The Closure Plan received conditional approval in September 1992. The closure consisted of removal and decontamination of the tank and associated piping and removal of contaminated soils adjacent to the tank. Closure activities were completed in May 1993.

X-751 Mobile Equipment Garage. The three buried fuel tanks, two 15,000 gallon gasoline tanks and one 550 gallon diesel fuel tank, were filled with concrete and abandoned in place subsequent to the RFI.

Peter Kiewit Landfill. In November 1994, as part of the selected IRM for Peter Kiewit Landfill, 1,000 ft of Big Run Creek was moved to the east and a leachate collection system was installed in the old creek channel. In 1996, the gravel collection drains near the seeps were extended toward the seeps to enhance leachate collection capability. As part of this action, a compacted soil layer was installed over the collection system and eastern slope to promote surface water runoff. Corrective measure implementation at this landfill, which began in July 1997, included placement of an engineered cap that met RCRA subtitle D requirements. The cap consists of a recompacted clay layer, a geomembrane liner, a properly sloped drainage layer, and a vegetative layer at least 30 in. deep to prevent frost damage to the cap materials and was completed in September 1998. The completion of an additional IRM in the fall of 1997 included an extension of the existing seep collection system.

Big Run Creek and Unnamed Southwest Drainage Ditch. Big Run Creek and the unnamed Southwest Drainage Ditch have been investigated as part of a site-wide drainage ditch radiological survey. The data presented in the *Data Assessment and Risk Evaluation Report for Big Run Creek and the Southwest Drainage Ditch* (DOE 1997) showed that the ELCR at Big Run Creek and the unnamed Southwest Drainage Ditch from radionuclides in sediment and surface soils are not currently of concern nor are they expected to be of concern in the future.

1.4 RFI DATA EVALUATION

The purpose of the Quadrant I CAS/CMS is to identify, develop, and evaluate remedial alternatives to eliminate or reduce to acceptable levels any risks to human health or the environment posed by releases of contaminants. This effort relies on data generated during Phases I and II of the *Quadrant I RCRA Facility Investigation Final Report*, which was approved in September 1997 (DOE 1996a). The environmental setting of Quadrant I and the PORTS facility are well understood as a result of this and previous investigations. In addition, background levels of naturally occurring constituents have been determined and are specified in the *Background Sampling Investigation of Soil and Groundwater Final Report* (BSI) (DOE 1996c).

Details of the Air RFI are included in the *Final Air Pathway RCRA Facility Investigation Report* (DOE 1997a).

The CAS/CMS effort also relies on subsequent studies and environmental monitoring data. Appendix A contains analytical data for all constituents detected in Quadrant I.

1.4.1 Summary of RFI Activities

Much of the RFI involved contaminant data collection; however, background studies, groundwater modeling, and risk assessments also were conducted. The scope of work for these activities is summarized in Sections 1.4.1.1 through 1.4.1.4, and results are summarized in Section 1.4.2.

1.4.1.1 Phases I and II RFI contaminant data collection

Fieldwork for Phases I and II of the RFI was conducted from February to August 1991 and from October to December 1993, respectively. All media, except air, were investigated during the RFI; the scope of air-related RFI activities was negotiated with the Ohio EPA and the U.S. EPA. The *Final Air Pathway RCRA Facility Investigation Report* was submitted to U.S. EPA and Ohio EPA on November 1, 1996 (DOE 1997a).

Twenty-three SWMUs were investigated during Phases I and II of the Quadrant I RFI. During the RFI, soil, sediment, surface water, and groundwater sampling, proposed in the approved *Quadrant I RFI Work Plan* (Geraghty & Miller, Inc., 1992b) and *Quadrant I RFI Phase II Work Plan* (Geraghty & Miller, Inc. 1994), was conducted as specified in the approved work plans and the *RFI Sampling Plan* (Geraghty & Miller, Inc. 1992b). No data were collected for the X-231B Southwest Oil Biodegradation Plot and only limited amounts of data were collected for the X-749 Landfill because of ongoing closure activities.

Comprehensive analyses of soil and sediment samples were conducted at each unit, where applicable, for Target Compound List (TCL)/Target Analyte List (TAL) constituents listed in the *Statement of Work for Organic Analyses for Soil and Sediment* (U.S. EPA 1988a) and *Statement of Work for Inorganic Analyses for Soil and Sediment* (U.S. EPA 1988b). RFI Phase I surface water and groundwater samples, where applicable, were analyzed for the Appendix IX list of constituents from 40 CFR Part 264. On the basis of requirements of the U.S. EPA and Ohio EPA, RFI Phase II samples were analyzed for parameters determined by review of Phase I analytical results. Both solid and liquid samples were analyzed for fluoride, Freon-113, and radiological parameters (gross alpha, gross beta, total uranium, and technetium). Additional analyses for transuranic elements (neptunium and plutonium) and uranium isotopes (^{234}U, ^{235}U, and ^{238}U) were performed on 5 percent of all samples during Phase I. During the Phase II investigation, selected samples were analyzed for transuranic elements and uranium isotopes specified in the *Quadrant I RFI Phase II Work Plan* (Geraghty & Miller, Inc. 1994). In addition, samples that exhibited a total uranium concentration of greater than 25 ppm were analyzed by the PORTS laboratory for the transuranic elements and isotopic uranium.

1.4.1.2 Background sampling investigation

An initial background investigation was conducted in 1991 as part of the RFI draft reports for Quadrants I and II (DOE 1994a, 1994b). Results from this investigation are referred to as tentative background data. On the basis of these results, the Ohio EPA and the U.S. EPA determined that additional samples from locations off the DOE reservation should be collected to adequately characterize background levels of metals and naturally occurring radiological parameters in soil and groundwater. Results of the second background sampling investigation were approved by the Ohio EPA and the U.S. EPA Region V in July 1996 (DOE 1996c). Upper tolerance limits (UTLs) for soil and groundwater were established in the report. The use of UTLs as screening values is discussed in Chapter 3 of this CAS/CMS. Background investigations of surface water and sediment have not been conducted.

1.4.1.3 Baseline risk assessment

The Quadrant I baseline risk assessment (BRA) provides the following information:

- contaminants of potential concern (COPCs),
- exposure assessment,
- toxicological assessment,
- risk characterization,
- preliminary ecological risk assessment (PERA), and
- conclusions.

Sampling data were summarized on a SWMU-specific basis to determine the chemicals detected in each medium. The detected chemicals were designated COPCs. During the exposure assessment, potential human exposure pathways were identified, environmental concentrations were estimated at points of potential exposure, and human dose or intake values were estimated. A complete discussion of COCs and PRGs is presented in Chapter 3.

In the BRA, pathways for potential exposure to contaminants were considered under the current land use scenarios (off-site resident, off-site recreational population, and on-site worker) and the future land use scenarios (on-site resident, on-site recreational population, and on-site worker). Unless otherwise indicated, all pathways were modeled for each receptor as follows:

- groundwater through ingestion of drinking water, dermal contact, and inhalation of volatiles while showering (future on-site worker and resident);
- shallow soil through incidental ingestion and dermal contact and by external gamma radiation from radionuclides present in the soil;
- sediment through incidental ingestion and dermal contact;
- surface water through incidental ingestion and dermal contact;
- air through inhalation of vapors and particulates;
- ingestion of vegetables grown on and beef and milk from cattle pastured on contaminated land (future on-site resident);
- ingestion of local game contaminated by grazing on land affected by plant operations (current off-site and future on-site recreational visitors); and
- ingestion of fish from local tributaries (current off-site and future on-site recreational visitor).

The BRA considered only exposure to shallow soil (0 to 10 ft). Deep soil, defined as greater than 10 ft below ground surface, was assumed to pose a threat primarily to groundwater if contaminated. Hence, pathways involving exposure to soil, such as incidental ingestion, are not applicable to deep soils. Exposure to soil for the current use scenario considers soil from 0 to 2 ft, and the future use scenario considers soil from 0 to 10 ft.

Toxicity values of COPCs were used to estimate potential incidence of adverse human health effects that may occur at different exposure levels. The BRA did not evaluate risk for a given constituent if that constituent had no agency-approved toxicity values. The risk characterization provides numerical estimates of carcinogenic and noncarcinogenic risks and the major uncertainties related to the estimates. Tentative concentrations of naturally occurring compounds in soil, based on the 95 percent upper confidence limit (UCL) of the calculated mean, were used to assess the potential risks from background, as opposed to those risks that may be related to activities at PORTS. Although background levels have since been revised and characterized in the BSI, the revised background values were not approved until after the assessment of risk for Quadrant I SWMUs had been completed. Therefore, approved background values presented in the BSI are not incorporated into the Quadrant I RFI. Revised and approved background concentrations in soil and groundwater are evaluated in this CAS/CMS to eliminate COPCs when maximum concentrations were below their respective background concentrations.

The BRA criteria used to evaluate risk include the hazard index (HI) for noncarcinogenic effects and the excess lifetime cancer risk (ELCR) for carcinogenic effects. If the HI is 1 or less, exposure to the chemical would not be expected to result in adverse effects. If the HI is greater than 1, the potential for adverse effects under the assumed exposure conditions is increased. Generally, regulatory agencies have judged ELCR estimates of less than 1 in 1 million (10^{-6}) to be insignificant. However, the National Contingency Plan (NCP) at 40 CFR 300.430(e)(2)(I)(A)(2) states that "for known or suspected carcinogens, acceptable exposure levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6} using information on the relationship between dose and response." Therefore, the target risk levels used in the baseline risk assessment are an HI of 1 and an ELCR of 10^{-4} to 10^{-6}. An ELCR of 10^{-6} has been used in this CAS/CMS to determine PRGs and to analyze best available technologies for remediation activities.

The RFI BRA categorized SWMUs into one of three general groups on the basis of potential carcinogenic and noncarcinogenic risks (target risk level not exceeded, ELCR # 10^{-6} or HI # 1; within target risk levels, ELCR between 10^{-4} and 10^{-6}; target risk levels exceeded, ELCR $> 10^{-4}$ or HI > 1) by using reasonable maximum exposure (RME) to environmental media for a hypothetical future on-site resident. Since the completion of the RFI and the BRA, the PORTS Decision Team has determined that the industrial areas of the site (primarily within the Perimeter Road) will likely remain industrial in the future and the remaining property will be evaluated for risk on the basis of a commercial or recreational scenario. Therefore, the on-site residential risk scenario is not considered in this report. Summaries of the applicable risks calculated for each SWMU in Quadrant I are presented in Chapter 2 of this report.

1.4.1.4 Ecological risk assessment

The ecological risk assessment process was conducted in two steps. The first step was to generate a separate Preliminary Ecological Risk Assessment (PERA) for each quadrant. The Quadrant I PERA was conducted as part of the Quadrant I BRA to compile existing fate, exposure, and toxicity information (including that collected during the RFI) and to evaluate this information by using a screening process to focus the sitewide BERA that followed. Specifically, the PERA identified and screened the potential for ecological risks posed by COCs at each SWMU. The PERA identified the watersheds within the quadrant, determined which SWMUs are in each watershed, and summarized the biotic community types within the quadrant. To accomplish the PERA, screening benchmarks for adverse ecological effects were developed for each chemical constituent in each environmental medium (e.g., sediment, surface water, and soil) evaluated during the RFI.

The second step was to conduct a BERA to determine the current and future impact of releases from PORTS on ecological receptors. The BERA focused on the Little Beaver Creek and Big Run Creek watersheds and the northwestern, western, and southwestern tributaries. Ecological risks are discussed for each watershed or tributary.

Potential endpoint receptors identified during the BERA include aquatic species (fish and benthic macro invertebrates), terrestrial species (vascular plants, soil invertebrates, vole, short-tailed shrew, and American woodcock), and piscivorus species (belted king fisher and mink). Wetland and threatened species are also addressed in the BERA (DOE 1996b).

Characterization of risks to ecological receptors requires consideration of all available evidence; this includes historical data collected by the Ohio EPA and DOE and data collected specifically for the purpose of ecological risk assessment. Three distinct lines of evidence are provided in the BERA: single-chemical toxicity data, media toxicity data, and biological survey data (DOE 1996b).

All Quadrant I SWMUs are within the Big Run Creek and southwestern tributary watersheds. Therefore, only conclusions pertaining to the Big Run Creek and southwestern tributary watersheds are presented in this CAS/CMS report. Big Run Creek watershed data was collected before a 1,000-ft section of the creek was relocated in the fall of 1994.

Available evidence indicates potential risk to fish in Big Run Creek. Chemical analyses suggest that the contamination may be sufficient to cause mild toxicity; however, comparison of this data with values obtained from the reference site indicate no statistically significant difference.

Chemical contaminants in the southwest tributary contributed a negligible risk to the fish community. Biological survey results indicate a degraded community that results from the poor habitat quality (i.e., lack of terrestrial plant community structure adjacent to the stream).

No statistically significant difference was discerned in whole sediment toxicity tests for organism survival at Big Run Creek and the southwestern tributary relative to the corresponding reference site sediments. The benthic community in the southwestern tributary may be impacted by the analytes that exceed benthic toxicity benchmarks. The benthic community may also be impacted by the tributary's low water flow. Qualitative evaluation of the benthic community in the southwestern tributary indicates that the community has a high degree of toxanomic diversity and species richness.

The weight of evidence suggests the possibility that plant growth may have been limited by Big Run Creek alluvial soils. Alluvial soil phytotoxicity tests showed a greater than 20 percent reduction in growth of plants in these soils; however, test results were not statistically significant. Big Run Creek watershed

contained concentrations of cobalt in soils that exceeded phytotoxicity benchmarks. Big Run Creek watershed also contained a number of constituents for which benchmark information is unavailable for comparison.

Big Run Creek watershed alluvial soil invertebrate toxicity tests showed a 33 percent decrease in growth of earthworms (*Eisenia foetida*). This difference was not statistically significant when compared with the reference site.

The southwestern tributary evidence suggested a slight possibility that plant growth may be limited in the alluvial soils. Zinc concentrations that exceeded the toxicity benchmarks were found; however, soil toxicity tests using alluvial soils from the southwestern tributary watersheds show an adverse effect on earthworms (*Eisenia foetida*).

The wildlife communities in the Big Run Creek and southwestern tributary watersheds do not appear to be experiencing significant ecological perturbation.

1.4.1.5 Air pathway RFI

A phased approach was employed during the PORTS Air RFI so that the observations and findings from each phase could be incorporated into successive phases of the investigation. Phase I consisted of on-site and ambient air sampling during normal operation of the facility and Lockheed Martin Utility Systems stack and vent inventory. Phase II included a review of RFI data and reports and a walkdown evaluation and inventory of SWMUs. Emission and dispersion modeling of area sources and point source emissions took place in Phase III. Emission sampling of potential area sources identified by Phases II and III was completed as Phase IV.

Data collected during the Air RFI (DOE 1997a) indicate that certain air contaminants are emitted in low concentrations from sources at PORTS. These contaminants were detected in on-site and off-site ambient locations. On the basis of data comparisons of average upwind concentrations with average downwind concentrations and additional information collected during the phased approach of the Air RFI, ambient air impacts from the PORTS facility are negligible.

1.4.2 Data Summary and Evaluation

The objective of the data evaluation exercise is to determine if RFI data, as well as data collected subsequent to the RFI, are sufficient for the CAS/CMS process. This evaluation is summarized in the following sections.

1.4.2.1 Contaminant data

Appendix A presents the parameters detected at each SWMU, including sample locations and concentrations. Data regarding the nature of contamination are considered sufficient and adequately confirms the presence or absence of the COPCs and their respective maximum concentrations within each medium. Data regarding the extent of contamination are considered sufficient to allow development and analysis of potential remedial alternatives.

Inorganics and naturally occurring radiological parameters were not fully evaluated in the RFI because background levels were not finalized. These background levels have now been established and are used in the development of PRGs in the CAS/CMS (See Chapter 3). If the evaluation indicates a potential release of inorganic or radiological constituents, then the area of concern is further evaluated to determine if the extent and degree of contamination are adequately defined to enable development of remedial alternatives or evaluate incremental risk above PRGs.

Shallow Soil. The shallow soil (0 to 10 ft deep) data collected during Phases I and II of the RFI and studies subsequent to the RFI are sufficient for use in the CAS/CMS process. Volume estimates are based on sample locations with detections at concentrations exceeding PRGs. Possible sources of the contaminants, topography of the area affected, and possible migration pathways were considered when estimating volumes. The volume estimates derived during evaluation of the area are sufficient for the CAS/CMS process and for selecting the best available remediation technology.

Deep Soil. Deep soil (greater than 10 ft) data are sufficient for use in the CAS/CMS process.

Because deep soil contamination is primarily a potential threat to groundwater, deep soil cleanup objectives must be developed on the basis of contaminant fate and transport in the subsurface. A vadose zone soil leaching report (DOE 1994c) was prepared for PORTS to establish a methodology for determining cleanup goals for deep soil contamination. This report has been approved by the Ohio EPA. The screening process to determine if deep soil contamination exists is discussed in Chapter 2 of this CAS/CMS report.

Surface Water. Surface water data collected during Phases I and II of the RFI and sampling subsequent to the RFI are sufficient for use in the CAS/CMS process. No additional data are required with respect to the nature or extent of surface water contamination.

Sediment. Sediment data collected during Phases I and II of the RFI and subsequent to the RFI are sufficient for use in the CAS/CMS process. No additional data are required with respect to the nature or extent of sediment contamination.

Groundwater. Groundwater data collected during Phases I and II of the RFI for organic contaminants, as well as data from subsequent sampling events, is sufficient for use in the CAS/CMS process. Data for inorganic parameters, however, may result in overestimation of the concentration and extent of metals and radiological parameters. Because much of the data was derived from groundwater samples that were not filtered prior to analysis, colloid-sized particles found in the turbid samples biased metals and radiological levels upward. While these data cannot be used to entirely define the extent of contamination related to inorganic constituents, they are useful with respect to determining inorganic COCs. Analytical results from unfiltered metals and radionuclide samples can serve as conservative upper limits of contamination. If these conservative values are screened against PRGs and are found to be of no concern, then no further action under the CAS/CMS process would be necessary. If areas of contamination are determined to be above established PRGs, additional data will be developed to properly evaluate those areas.

To address problems associated with turbid samples, the Phase II Investigation included groundwater sampling for total mobile (5.0-micron-filtered) metals. These samples were collected at only a few locations where potential inorganic contamination was suspected. Off-site background sampling was also conducted, and UTLs were calculated for total mobile metals in accordance with U.S. EPA risk assessment guidance (U.S. EPA 1989).

Changes in the sampling procedure for metals and radiological parameters in groundwater to a less disruptive and more consistent sampling method are being initiated and additional data are being developed through the IGWMP. Low-flow pumps have been used to collect groundwater samples from selected Quadrant I monitoring wells. Preliminary results indicate that samples collected with these pumps are lower in turbidity and have significantly lower concentrations of metals. This sampling technique has been incorporated in the IGWMP. Further details regarding this groundwater monitoring plan can be found in Chapter 2.

1.4.2.2 Background data

UTLs for soil, Berea Sandstone, and Gallia unit groundwater are provided in the background report (DOE 1996c) and are presented in Appendix C.

Soil. With the exception of data on antimony in soil, background soil data are sufficient to support the CAS/CMS process. Antimony soil data were declared unusable during the validation process because of poor matrix spike and duplicate recovery and because sample results were less than the practical quantization limit. For these reasons, the background antimony UTL was not determined.

Groundwater. Groundwater background data for gross alpha, gross beta, and metals presented in the background sampling investigation (DOE 1996c) are sufficient to support the CAS/CMS process. UTLs generated for the Gallia and Berea groundwater are method-specific tolerance limits. All groundwater samples collected during the background investigation were collected by using bailers, and UTLs were calculated by using the total mobile (5.0-micron-filtered) metals results (except for fluoride, gross alpha, gross beta, and total uranium, for which UTLs were calculated by using the unfiltered metals results). U.S. EPA risk assessment guidance (U.S. EPA 1989) requires risk calculations for inorganic data to be conducted only on unfiltered sample results.

1.4.2.3 Risk data evaluation

The BRA presents sufficient data to enable evaluation of the need for remediation of SWMUs in Quadrant I. However, uncertainties associated with the BRA must be considered and are summarized in the following paragraphs. Intake rates were evaluated for each medium, frequency, and duration of exposure for each exposure pathway. In the absence of site-specific data, the assumptions used in the BRA are consistent with the U.S. EPA guidance for deriving estimates of the RME case (U.S. EPA 1989, 1990, 1991).

The evaluation of risk from exposures to groundwater is based on the evaluation of total metals concentrations specified in the U.S. EPA guidance (U.S. EPA 1989). The analysis for total metals reflects the concentrations of metals dissolved in groundwater and a component induced by suspended sediment. Consequently, use of total metals concentrations may overestimate the risk posed by actual water-bearing unit conditions.

The data presented in the BERA are adequate for use during the CAS/CMS process. The BERA conclusions pertaining to Quadrant I recommend no remediation for protection or restoration of the fish or wildlife communities. Nor is remediation recommended for sediments in regard to benthic communities or for alluvial soils in regard to plant and invertebrate communities.

1.5 ARARS IDENTIFICATION AND EVALUATION

The CAS/CMS process at PORTS is based on binding agreements entered into by the Ohio EPA, U.S. EPA, and DOE. The U.S. EPA AOC and the Ohio EPA Consent Decree require DOE to investigate and remediate hazardous constituents at PORTS according to RCRA corrective action requirements.

However, the AOC requires that CERCLA requirements be integrated into the corrective action process as ARARs or regulatory drivers to address releases of hazardous substances that are not hazardous waste.

To ensure protection of human health and the environment, Section 121 of CERCLA specifies that remediation of hazardous substances must comply with ARARs consisting of federal or more stringent state environmental laws and policies. Applicable requirements are "those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant, contaminant, remedial action, or other circumstance at a CERCLA site" (40 CFR 300.5). Relevant and appropriate requirements are "those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not applicable to a hazardous substance, pollutant, contaminant, remedial action, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at a CERCLA site that their use is well suited to the particular site" [40 CFR 300.400(g)(2)].

In the absence of regulations promulgated by the state or federal governments, many criteria, advisories, guidance values, and proposed standards that are not legally binding may serve as useful guidance for setting protective cleanup levels. These are not ARARs but are to-be-considered (TBC) guidance.

1.5.1 Summary of ARARs and TBC Guidance

A summary of preliminary ARARs and TBC guidance pertinent to the remedial actions evaluated in this CAS/CMS is presented in Appendix B. The ARARs are categorized as chemical-, location-, and action-specific.

1.5.2 Chemical-Specific ARARs

Chemical-specific ARARs establish health- or risk-based concentration limits or discharge limitations for various media and for specific hazardous substances, pollutants, or contaminants (53 FR 51394). These requirements generally set protective cleanup levels for the COCs in the designated media or indicate a safe level of discharge that may be incorporated when considering a specific remedial activity.

1.5.3 Location-Specific ARARs

Location-specific ARARs set restrictions on the concentration of hazardous substances or the conduct of activities solely because they are in special locations (53 FR 51394). In determining the use of location-specific ARARs for selection of remedial actions at PORTS, individual SWMUs were reviewed for location-specific requirements.

1.5.4 Action-Specific ARARs

Performance, design, or other action-specific ARARs set controls or restrictions on particular activities proposed as remedial alternatives (53 FR 51394). The selection of a particular remedial action, such as removal and incineration, invokes specific performance standards and specific concentration levels for discharged or residual chemicals.

1.6 REFERENCES

Adams, J. 1994. *Technical Memorandum for the Portsmouth Gaseous Diffusion Plant Baseline Ecological Risk Assessment: Wetland Survey*. Piketon, Ohio.

ASC Group, Inc. 1997. *Phase I Archaeological Survey for the Portsmouth Gaseous Diffusion Plant (PORTS Facility in Scioto and Seal Townships, Pike County, Ohio)*. Columbus, Ohio.

Bonnett, R. B., Noltimier, H.C., and Sanderson, D. D., 1991, *A paleomagnetic study of the early Pleistocene Minford Silt Member, Teays Formation*, West Virginia, in Melhorn, W. N., and Kempton, J. P., eds., Geology and hydrogeology of the Teays-Mahomet Bedrock Valley System, Boulder, Colorado, Geological Society of America Special Paper 258.

deMarsily, G. 1986. *Quantitative Hydrogeology*. Academic Press, Inc., New York.

DOE. 1993. *Quadrant I CAS/CMS Work Plan*. DOE/OR/12-1171/D2. Piketon, Ohio.

DOE. 1994a. *Quadrant I RCRA Facility Investigation Draft Report*. DOE/OR/11-1231/D2. Piketon, Ohio.

DOE. 1994b. *Quadrant II RCRA Facility Investigation Draft Report*. DOE/OR/11-1232/D2. Piketon, Ohio.

DOE. 1994c. *Vadose Zone Soil Leaching Report*. DOE/OR/12-1249/D1. Piketon, Ohio.

DOE. 1996a. *Quadrant I RCRA Facility Investigation Final Report*. DOE/OR/11-1308/V1&D3. Piketon, Ohio.

DOE. 1996b. *Baseline Ecological Risk Assessment*. DOE/OR/11-1316/D2. Piketon, Ohio.

DOE. 1996c. *Background Sampling Investigation of Soil and Groundwater Final Report*. DOE/OR/11-1323/D6. Piketon, Ohio.

DOE. 1996d. *Development of Calibrated Groundwater Flow and Transport Model for Evaluating Remediation Alternatives at Portsmouth Gaseous Diffusion Plant and Their Application to the*

Design of the X-120 Horizontal Well. MMESD B.13-007, Rev. 0.

DOE. 1997a. *Final Air Pathway RCRA Facility Investigation Report*. DOE/OR/11-1350/D3. Piketon, Ohio.

DOE. 1997b. *U.S. Department of Energy Portsmouth Annual Environmental Report Data For 1995*. POEF-LMES-86. Piketon, Ohio.

DOE. 1998. *1997 RCRA Annual Hazardous Waste Report*. POEF-LMES-186.

Energy Systems. 1989. *Groundwater Quality Assessment for Four RCRA Sites*. Piketon, Ohio.

Energy Systems. 1993. *Portsmouth Gaseous Diffusion Plant Environmental Report for 1992* ES/ESH-50. Piketon, Ohio.

Energy Systems. 1996. *Wetland Survey Report for the Portsmouth Gaseous Diffusion Plant*. POEF-LMES-106. Piketon, Ohio.

Energy Systems. 1997a. *U.S. Department of Energy Portsmouth Annual Environmental Report for 1995*. POEF-LMES-88. Piketon, Ohio.

Energy Systems. 1997b. *1996 Annual Threatened and Endangered Species Report*. DOE/OR/11-1569 and POEF-LMES-119. Piketon, Ohio.

Energy Systems. 1998. *1997 Annual Hazardous Waste Report*. POEF-LMES-186. Piketon, Ohio.

Fenneman, N. M. 1938. *Physiography of the United States*. Prentice-Hall, New York.

Geraghty & Miller, Inc. 1989. *Site-Wide Groundwater Flow Model*. Piketon, Ohio.

Geraghty & Miller, Inc. 1990. *Analysis of Long-Term Hydrologic Budget Data for the Portsmouth Gaseous Diffusion Plant*. Piketon, Ohio.

Geraghty & Miller, Inc. 1991. *Description of Current Conditions at the Portsmouth Gaseous Diffusion*

Plant. Piketon, Ohio.

Geraghty & Miller, Inc. 1992a. *Quadrant I Description of Current Conditions for the Portsmouth Gaseous Diffusion Plant*. Prepared for Martin Marietta Energy Systems. Piketon, Ohio.

Geraghty & Miller, Inc. 1992b. *Quadrant I RFI Work Plan for the Portsmouth Gaseous Diffusion Plant*. Prepared for Martin Marietta Energy Systems. Piketon, Ohio.

Geraghty & Miller, Inc. 1994. *Quadrant I RFI Phase II Work Plan*. *Portsmouth Gaseous Diffusion Plant*. Piketon, Ohio.

Goldthwait, R. P., 1991, *The Teays Valley problem, A historical perspective*, in Melhorn, W. N., and Kempton, J. P., eds., Geology and hydrogeology of the Teays-Mahomet Bedrock Valley System, Boulder, Colorado, Geological Society of America Special Paper 258.

HAZWRAP. 1993. *Internal Draft: Interim Measures Report for the X-749 Landfill and X-120 Area*. Piketon, Ohio.

Law Engineering Testing Company. 1978. *Gas Centrifuge Enrichment Plant Geotechnical Investigation*. Piketon, Ohio.

Law Engineering Testing Company. 1982. *Soil and Groundwater Investigations for the GCEP Landfill Pathways Analysis*. Piketon, Ohio.

Pettyjohn, W. A., and Henning, R. 1979. *Preliminary Estimate of Groundwater Recharge Rates, Related Streamflow, and Water Quality in Ohio*. Water Resources Center, Ohio State University. Columbus, Ohio.

USDA. 1990. *Soil Survey of Pike County, Ohio*. Washington, D.C.

U.S. EPA. 1988a. *Statement of Work for Organic Analyses for Soil and Sediment*. Washington, D.C.

U.S. EPA. 1988b. *Statement of Work for Inorganic Analyses for Soil and Sediment*. Washington, D.C.

U.S. EPA. 1989. *Risk Assessment Guidance for Superfund*. *Volume I: Human Health Evaluation Manual (Part A)*. *Interim find of Emergency and Remedial Response*. EPA/540/1-89/002.

Washington, D.C.

U.S. EPA. 1990. *Exposure Factors Handbook*. EPA/600/8-89/043. Washington, D.C.

U.S. EPA. 1991. *Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors."* OSWER Directive 9285.6-03. Washington, D.C.